ME 530.241: Electronics and Instrumentation
Lab 4: Function Generators, Oscilloscopes, and AC Signals

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Apparatuses Multimeter, Tektronix PS280 DC Power Supply, Tektronix TDS3014B oscilloscope, Tektronix CFG 253 function generator, leads, breadboard

Documents

1. This laboratory assignment.
2. CFG253 Signal Generator User Manual
3. TDS3014 Oscilloscope User Manual
4. TDS3014 Oscilloscope Training Manual

The above documents are available on the course web site here `http://dscl.lcsr.jhu.edu/ME530241_2010`.

1 Pre-Lab Exercises

1. Given two inductors with inductance L_1 and L_2, use the inductor equation, KVL, KCL, and circuit analysis mehods to derive the equation for the total equivalent inductance, L_T, of the following:

   (a) Two inductors in series.
   (b) Two inductors in parallel.

   You must show and justify every step in your derivation. You must show and justify every step in your derivation.
2. Exercise 4.3 of [1].
3. Exercise 4.4 of [1].
4. Exercise 4.21 of [1].
5. Exercise 4.29 of [1].
6. ~~Exercise 4.29 of [1].~~ (skip this duplicate).
7. Exercise 4.33 of [1].
8. Exercise 4.38 of [1].
9. Exercise 4.39 of [1].

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2 Signal Generators and Oscilloscopes

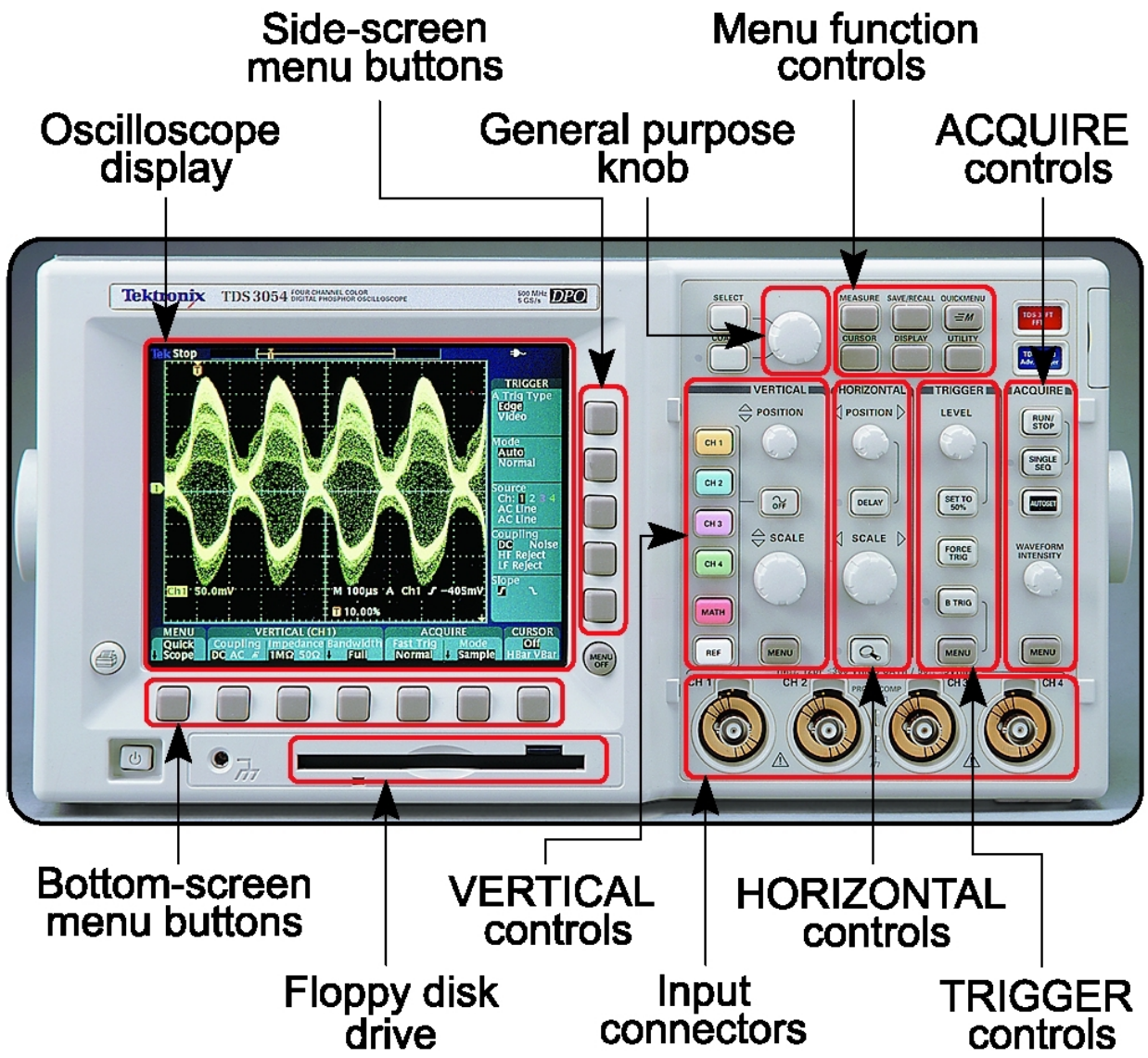

Figure 1: The Tektronix TDS3000 Series Digital Phosphor Oscilloscope.

2.1 Oscilloscope Probe Compensation

You will find two oscilloscope probes in your drawer. Connect them to the BNC connectors labeled CH1 and CH2. Follow the instructions given by your instructor (and on page 6 of your manual.) to check probe compensation for CH1. Repeat for CH2. Note what you are doing for your lab writeup. Note the magnitude and frequency of the test waveform.

2.2 Signal Generators and Periodic Waveforms

Switch on the signal generator power. Connect a BNC-to-Cliplead Test Lead to the MAIN output of the signal generator. Connect the CH-1 Oscilloscope probe to the signal generator output clipleads as instructed by the instructor. Using the signal generator instruction manual, configure

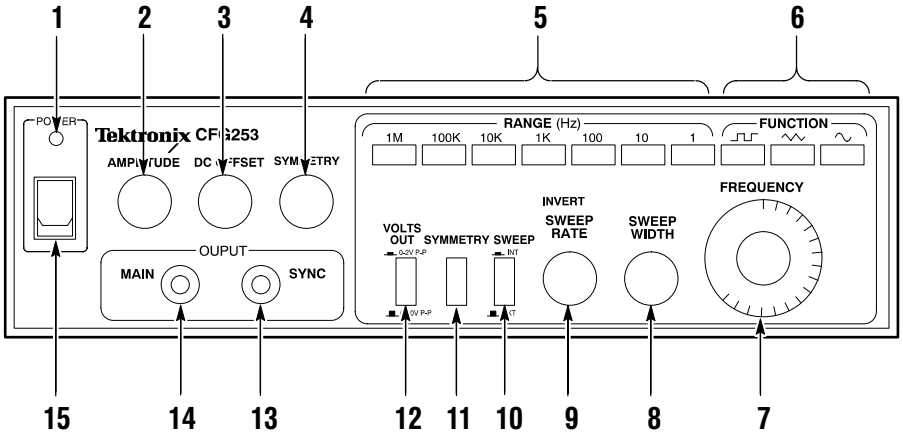

Figure 2: The Tektronix CFG253 Signal Generator. See manual for description of each function.

the signal generator to generate a sine wave that is approximately 10 Hz with 4V amplitude — i.e. 8V peak-to-peak.

Let's look at and measure some periodic waveforms.

1. Oscilloscope Basics – Acquiring and Displaying Signals. First, display CH1 on the scope and remove CH2 from the scope display; note that the CH1 MENU button toggles the display of CH1 on the screen.

   Experiment with the following oscilloscope controls and discuss them with your partner; if you are unsure of a function, look it up on the user's manual. If you are still unsure, discuss it with your instructor. In each case, note for your writeup the effect of each control i.e. briefly (but concisely) describe how the control effects the scope display.

   - RUN/STOP button
   - CH1 Menu button
   - Screen-menu controls in the CH1 Menu
   - CH1 Vertical position knob
   - CH1 Vertical scale knob
   - Horizontal position knob
   - Horizontal scale knob
   - Trigger Level knob
   - Trigger Slope

   Now, adjust the scope time (X-axis) to display approximately two periods of the waveform from the signal generator. Adjust the voltage (Y-axis) scale so that the waveform is at least 1/2 the height of the screen.

   There are two ways to get your data for inclusion in the lab report: 1) Using the web browser on the PC, go to the IP address of the oscilloscope to get a screen shot of the waveform for inclusion in your report or 2) Refer to the manual about how to print the plot directly to the printer. When using the web interface to

the oscilloscope, you should save all of your files to disk, and then either put them on a USB memory stick, e-mail them to yourself, use JShare, or, preferably, some combination of these options to ensure that you do not lose your data! When using the direct print interface, press the printer button to print a color copy of the screen on the lab printer. Note that both you and your partner will need to include the plot in your own lab report.

2. Signal Generator Basics – Generating Periodic Waveforms

   Experiment with the signal generator controls, observe the effect on the resulting waveforms, and discuss them with your instructor. In each case, note for your writeup the effect of each control i.e. briefly (but concisely) describe in words how the control effects the generator s output. You will have to re-adjust the scope display as the signal generator's output varies.

   - Frequency Range Buttons
   - Frequency Knob
   - Amplitude
   - DC Offset
   - Symmetry
   - Signal: square, triangle, sine

3. Generating and Measuring Periodic Waveforms with the Oscilloscope and Signal Generator

   Starting with the signal of the previous question, adjust the horizontal and vertical scale and position of your scope to make a single sinusoid fill much of the screen. Verify that the desired signal is being displayed.

   (a) Use the horizontal cursors to measure the peak-to-peak voltage of the signal, and adjust the signal generator to generate precise 4.0V amplitude (i.e. 8.0 volts peak-to-peak).
   Print and annotate[1] a copy of the measured signal for your lab report.

   (b) Use the vertical cursors to measure the zero-crossing to zero-crossing period of the signal, and adjust the signal generator nearly exactly to 1000 Hz.
   Print and annotate a copy of the measured signal for your lab report.

   (c) Enable the RMS auto-measure function. If any other auto-measurements are being displayed, remove them (ask your TA if you are unsure of this).
      i. Compute the theoretical RMS value of the specified signal.
      ii. Note the measured RMS value of this signal.
      iii. Compare.

   (d) Experiment with the Trigger Level knob.

   (e) What does the trigger do?

   (f) Vary the trigger level. Discuss what happens when the trigger level is too high or too low.

   (g) What does the trigger slope do? Print a plot, and annotate it to indicate the precise trigger position X and Y (time and voltage) on the plot. Be sure to indicate
      i. Trigger Channel
      ii. Trigger X position (time).

[1] What do we mean by "print and annotate"? On your plot, add written annotation showing the horizontal and vertical scale, and dimensions indicating that the waveform has the desired period, amplitude, and mean. Identify each waveform by label, i.e. "Node A", or "Voltage across the capacitor."

iii. Trigger Y position (voltage) graphical indicator.
iv. Trigger Y position (voltage) numerical value.
v. Trigger Slope

4. Repeat 3a — 3c for a 100 Hz square wave with -5V minimum and 0V maximum.

5. Repeat 3a — 3c for a 5000 Hz triangle wave with -5V minimum and +5V maximum.

6. Leaving your signal generator as configured for the previous question and displayed on CH1, use a probe on CH2 to connect to the scope's probe compensation test point. Experiment with switching the Trigger from CH1 to CH2, and from CH2 to CH1. Experiment with different Trigger voltage levels and slopes.

   Print and annotate one plot showing the scope triggering on CH2, and the two signals being displayed on CH1 and CH2, respectively.

7. Consult the CFG253 Signal Generator to determine the characteristic impedance X Ω of the main output of the device.

   Draw a circuit diagram of the CFG253 function generator which idealizes the device as a sinusoidal voltage source in series with a internal resistor of X Ω characteristic impedance.

   What will happen to the output signal of the signal generator when you attach an external resistor of X Ω? Draw the circuit and compute the expected result.

   Attach a resistor of X Ω to the output of the signal generator. Print and annotate a scope plot of the output WITH and WITHOUT this additional load resistor.

   Does the experimentally observed behavior (WITH and WITHOUT) agree with your calculations?

REMEMBER

- Note your lab partner's secret code on your lab report as well as your lab station number.
- Return all electronic test equipment and components to their proper location.
- Remember to show your work.
- Typewritten reports are not required, but messy or disorganized reports are unacceptable.
- Clean up your workstation to perfection when you are done.
- **Get your station checked off by your TA.**

References

[1] Giorgio Rizzoni. Fundamentals of Electrical Engineering. McGraw Hill, New York, 2009.

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My Secret Code	:
My Partner's Secret Code	:
Lab Date	:
Lab Station Number	:
Today's Date	:

You must have the T.A. inspect your lab station at the end of your lab session.

T.A. Signature and Date	: